1998 AGU Fall Meeting
San Francisco, CA, USA
6–10 December 1998

Dynamics of the Ring Current During Magnetic Storms: Measurements from the CRRES Spacecraft

A. Korth

MAX-PLANCK INSTUT FÜR AERONOMIE

LATLENBURG-LINDAU, GERMANY

R.H.W. Friedel

LOS ALAMOS NATIONAL LABORATORY,

LOS ALAMOS, NEW MEXICO, USA

C. Mouikis

MAX-PLANCK INSTUT FÜR AERONOMIE

LATLENBURG-LINDAU, GERMANY

J. Fennell

THE AEROSPACE CORPORATION, EL SEGUNDO, USA

J. Wygant

UNIVERSITY OF MINNESOTA, MINNESOTA, USA

Contents

A. Abstract

The dynamics of ions (H^+, He^+, He^{2+}, O^+) and electrons and the variation of the magnetic and electric field in the outer radiation belt (L=2.5 to L=7) during storms will be examined.

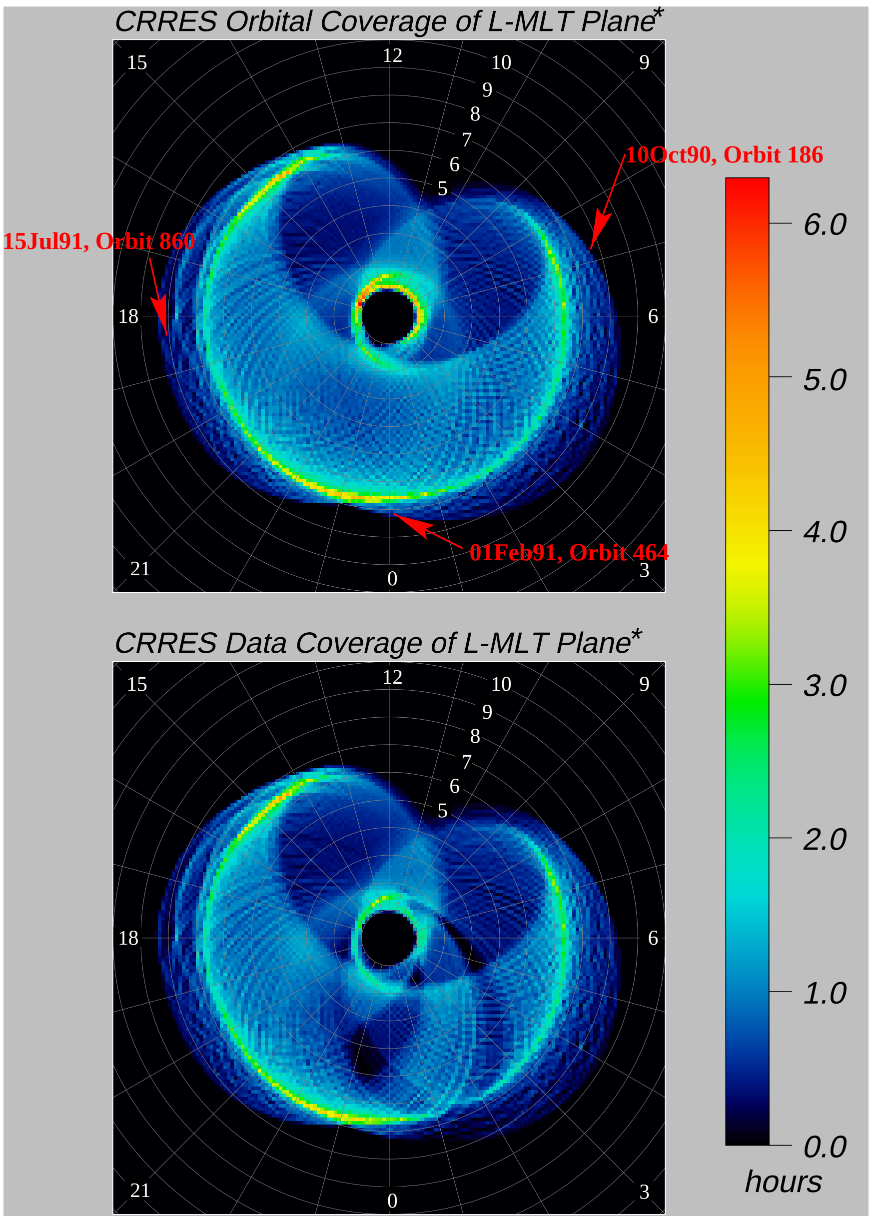
Due to interplanetary conditions and consequently due to the strength of the storm, the ring current is substantially modified and intensified. We compare the evolution of the ring current population to indicators of storm activity (such as Dst and AE) and try to time the beginning of the symmetric ring current. We find that the strength of the cross-tail electric field is critical in altering convection such that initially only a partial ring current is observed.

We investigate CRRES particle and electric and magnetic field data and present them in L versus time plots which are ideal to demonstrate the global aspect and long-term variations of storms. The time resolution is half an orbital period of CRRES (5.5 hours).

We here present storms observed in the morning, at midnight and in the afternoon sectors.

B. The CRRES Mission

CRRES (**C**ombined **R**adiatio **R**elease **E**ffects **S**atellite) completed 1072 orbits between July 1990 and August 1991 Its near-equatorial eccentric orbit was covers the regions from the inner radiation belts up to L=8 over magnetic local times from 08–16 hours.



C. Instrumentation and Data

This study uses the following particle spectrometers:

1. MEB (electrons and ions) [*Korth et al.*, 1992]
2. MICS (ion composition) [*Wilken et al.*, 1992]

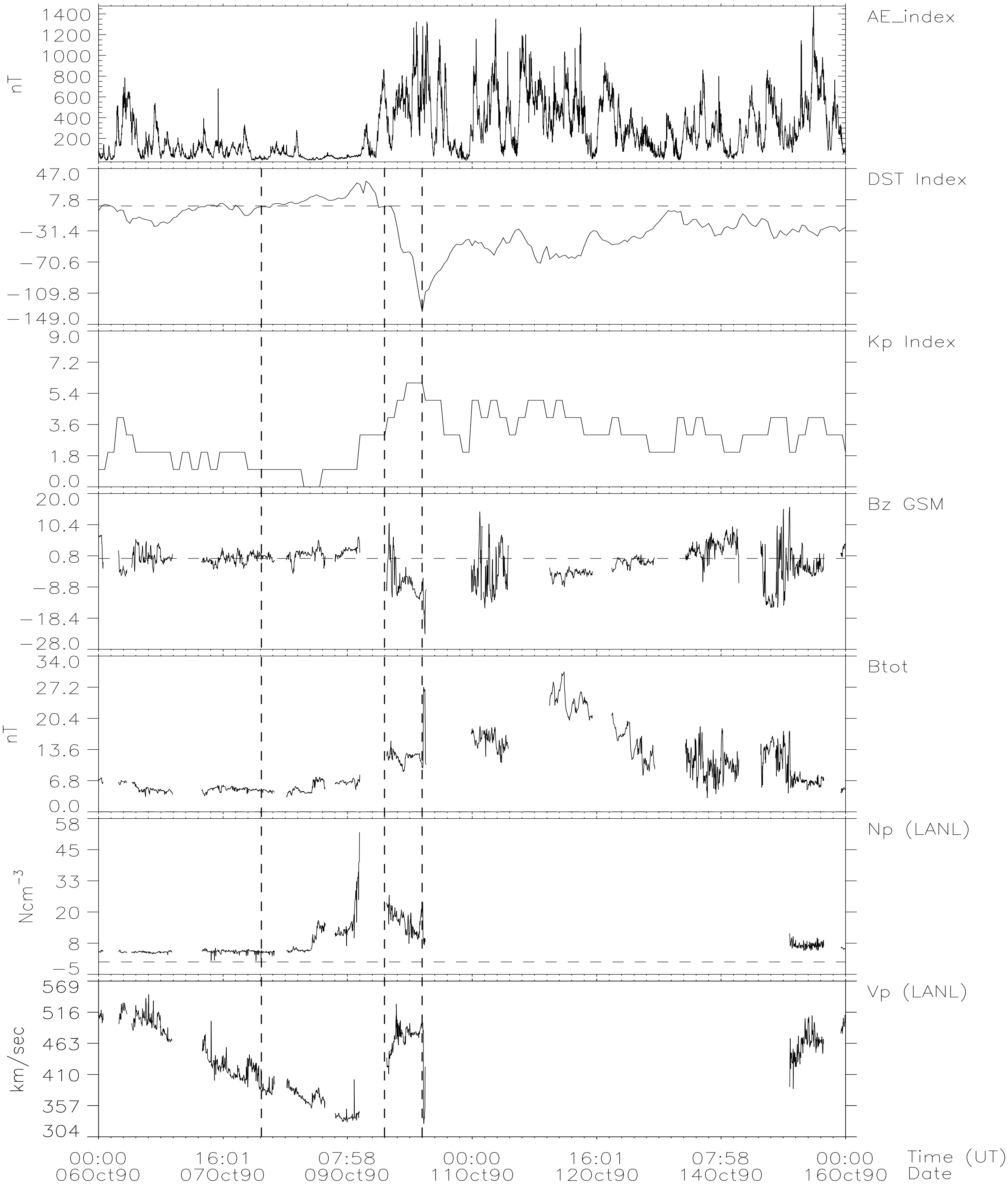
Further we use the following field instruments:

1. Magnetic Field [*Singer et al.*, 1992]
2. Electric Field [*Wygant et al.*, 1992]

Data is presented in the following manner:

- All data is split into half-orbit segments and binned in L-value. In the following plots each spectrum represents half an orbit of data, stacked in time.
- Particle data is corrected to the geomagnetic equator. MEB electrons below L=3.5 are contaminated by background.
- Electric field data E_y indicates the local cross-tail field.
- Magnetic field data in the VDH coordinate system is normalized with respect to a model field (Olsen & Pfizer 77). deviations from the model indicate a stretched or dipolar topography.

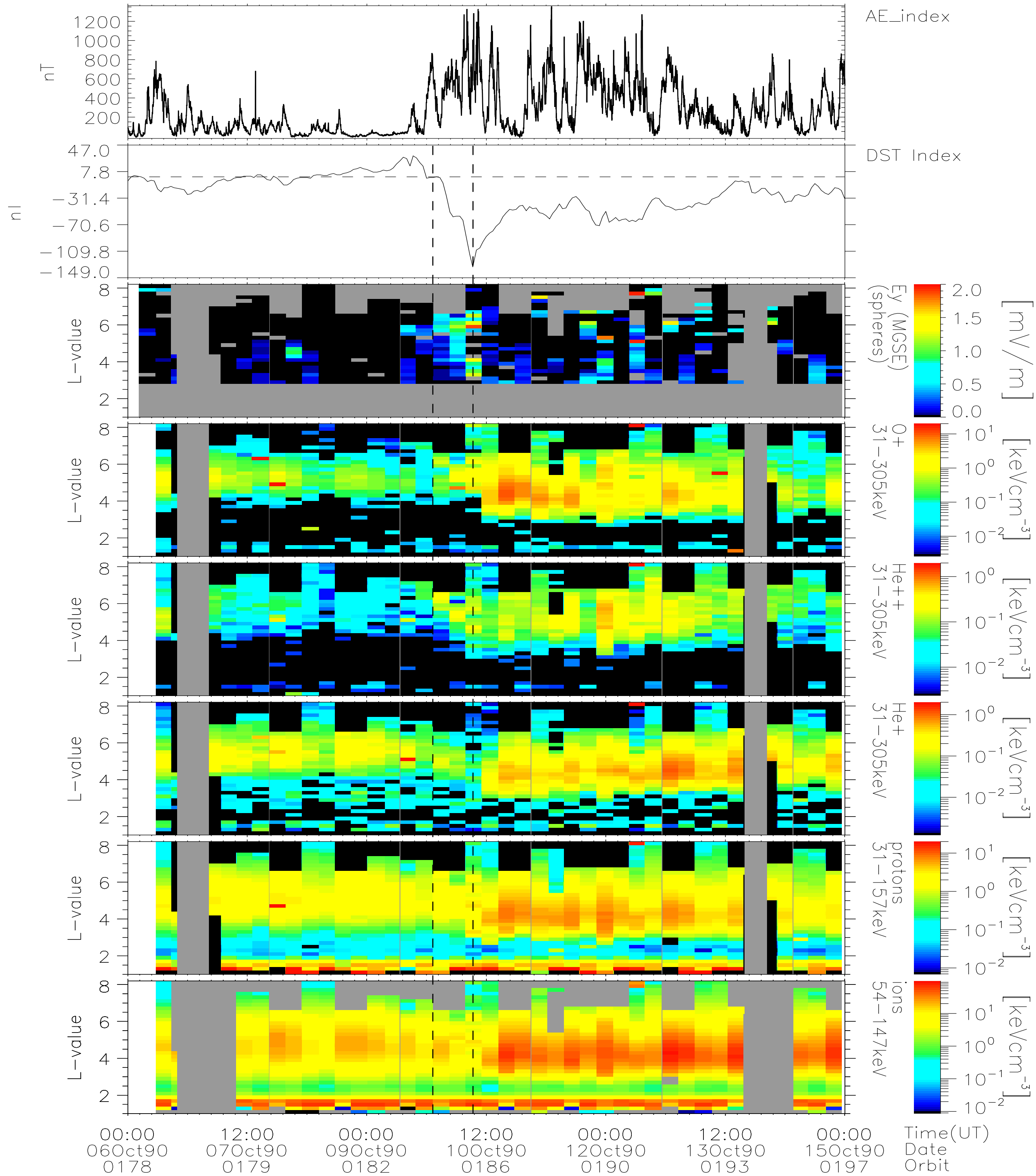
D.1 Morning Storm: Geomagnetic Conditions



Los Alamos NATIONAL LABORATORY

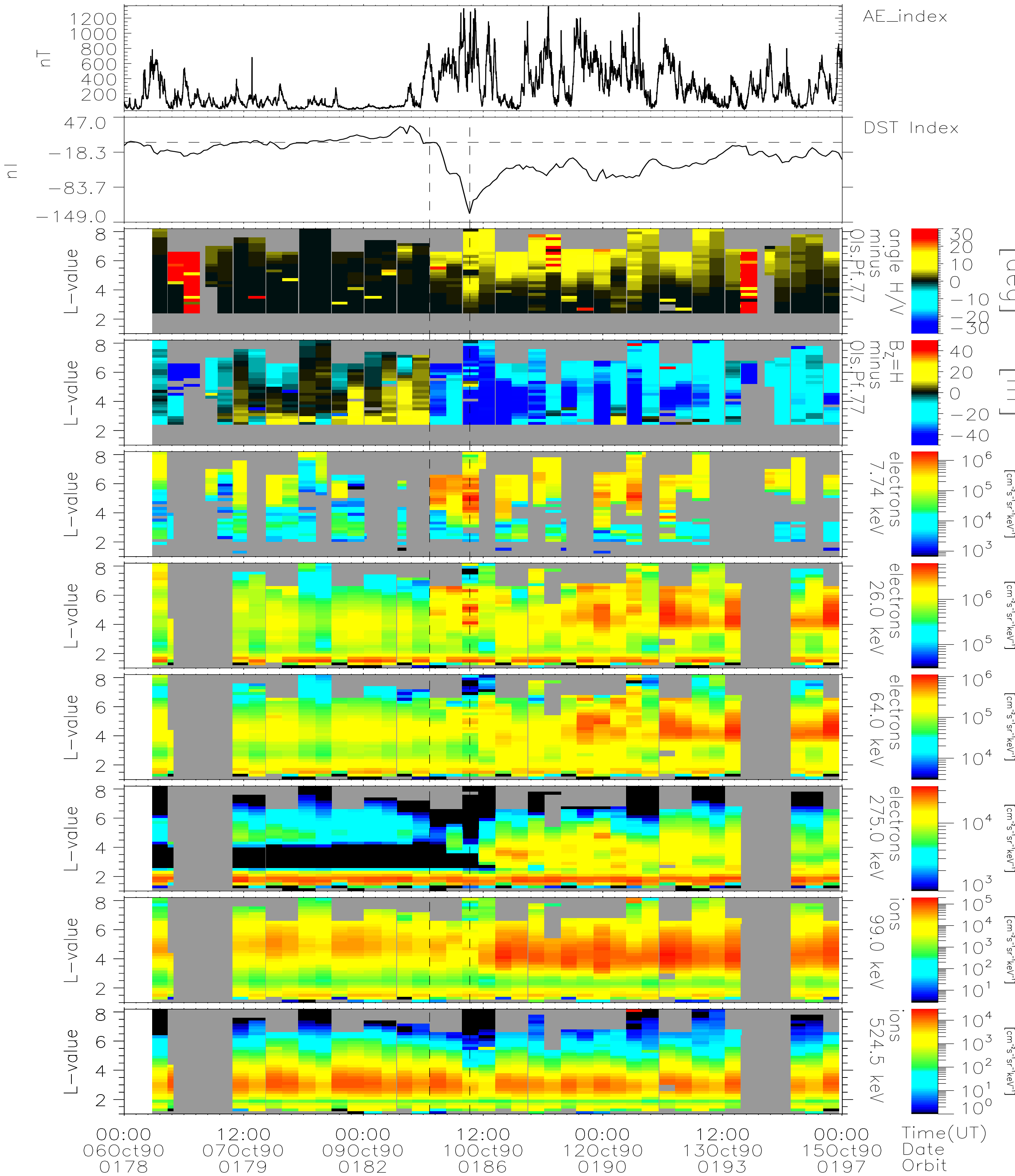
D.2a Morning Storm: Radiation belt conditions

The Energetic Particle Team
at Los Alamos National Laboratory



Los Alamos
NATIONAL LABORATORY

D.2b Morning Storm: Radiation belt conditions



D.3 Morning Storm: Discussion

The Energetic Particle Team at Los Alamos National Laboratory

- Storm occurred when CRRES apogee was near 05 MLT (See Section B). Classic southward turning of B_Z, recovery initiated by northward turning of B_Z.
- Large +ve angles of magnetic field H/V - model indicates strong stretching of field also on the morning side, starting during onset near L=6 and penetrating to L=5 during the main phase.
- Large electric field E_y indicates enhanced cross-tail field during onset and thus enhanced convection. The field goes to zero with the start of the recovery phase.
- Ring current ions intensify strongly the recovery phase only. very little is seen during onset. He^{+2} (solar wind origin) already has access to L=6 during onset but only intensifies at lower L a few days later.

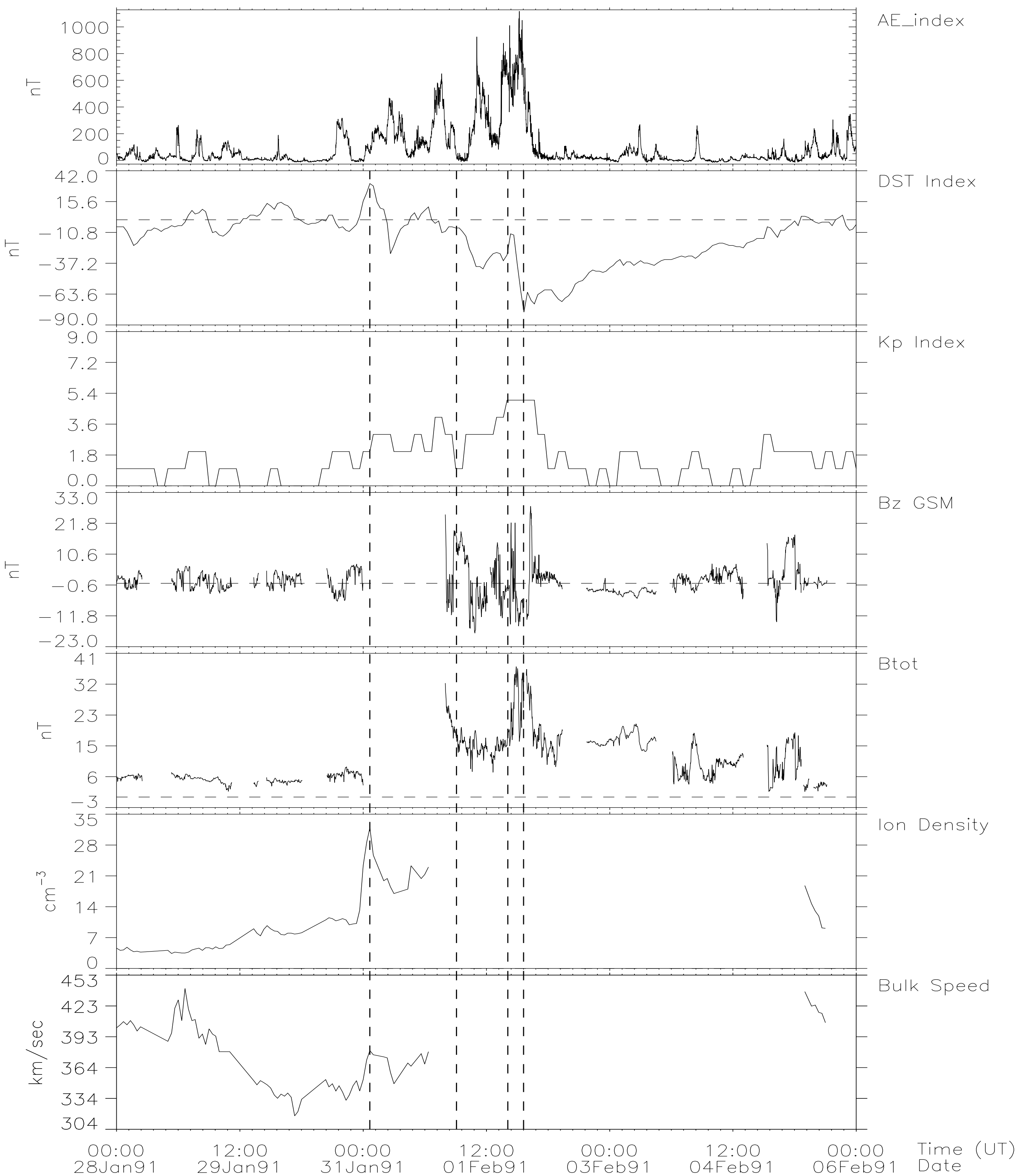
During storm onset large convection electric fields lead to drift paths for ring current ions which do not reach the morning side (drift paths move out to higher L and particles are lost at magnetopause which during storm onset moves further in). This leads to a partial ring current with the full symmetrical ring current only established during storm recovery when the electric field goes to zero.

Los Alamos NATIONAL LABORATORY

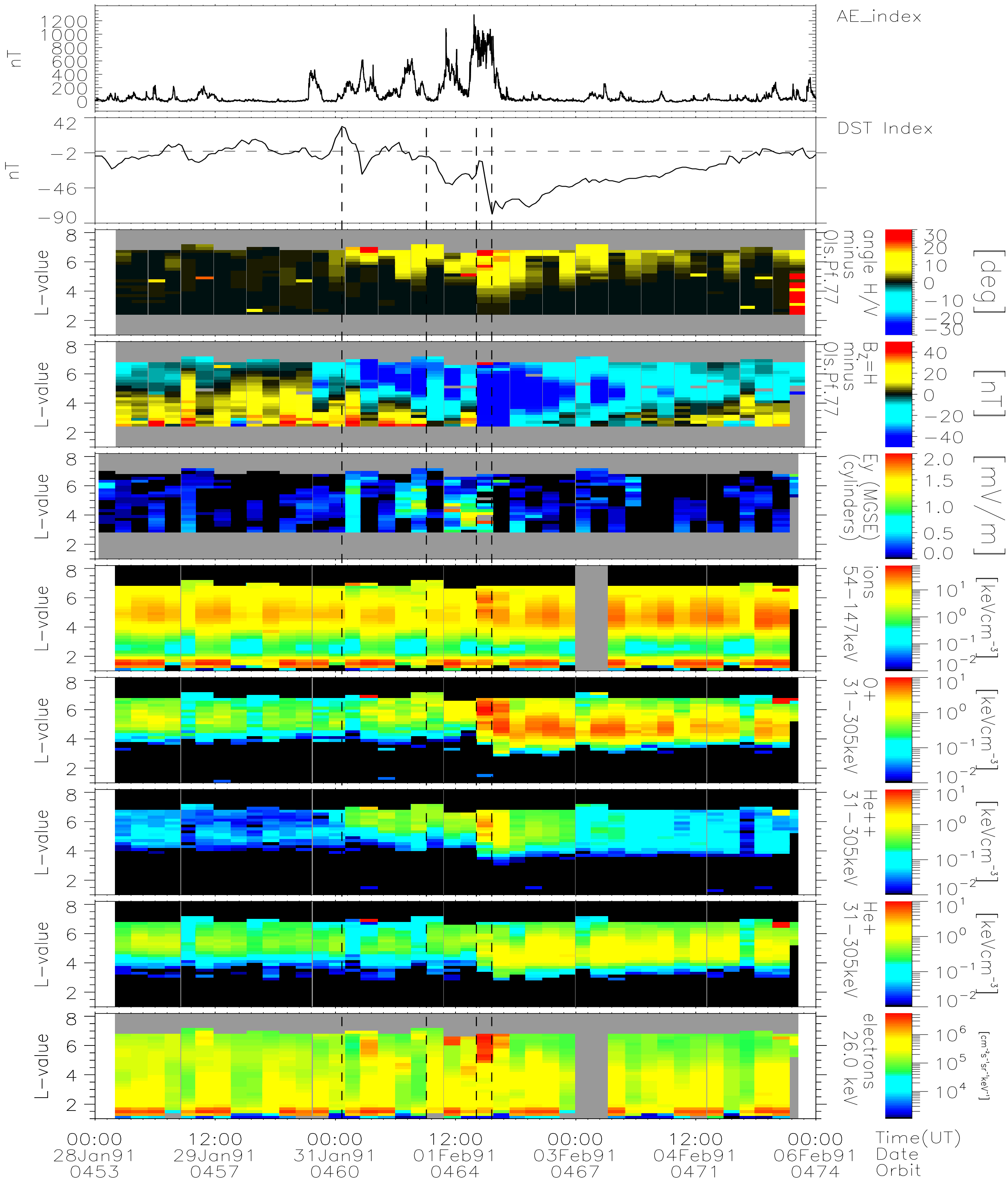
E.1

Midnight Storm: Geomagnetic Conditions

The Energetic Particle Team at Los Alamos National Laboratory



E.2 Midnight Storm: Radiation belt conditions

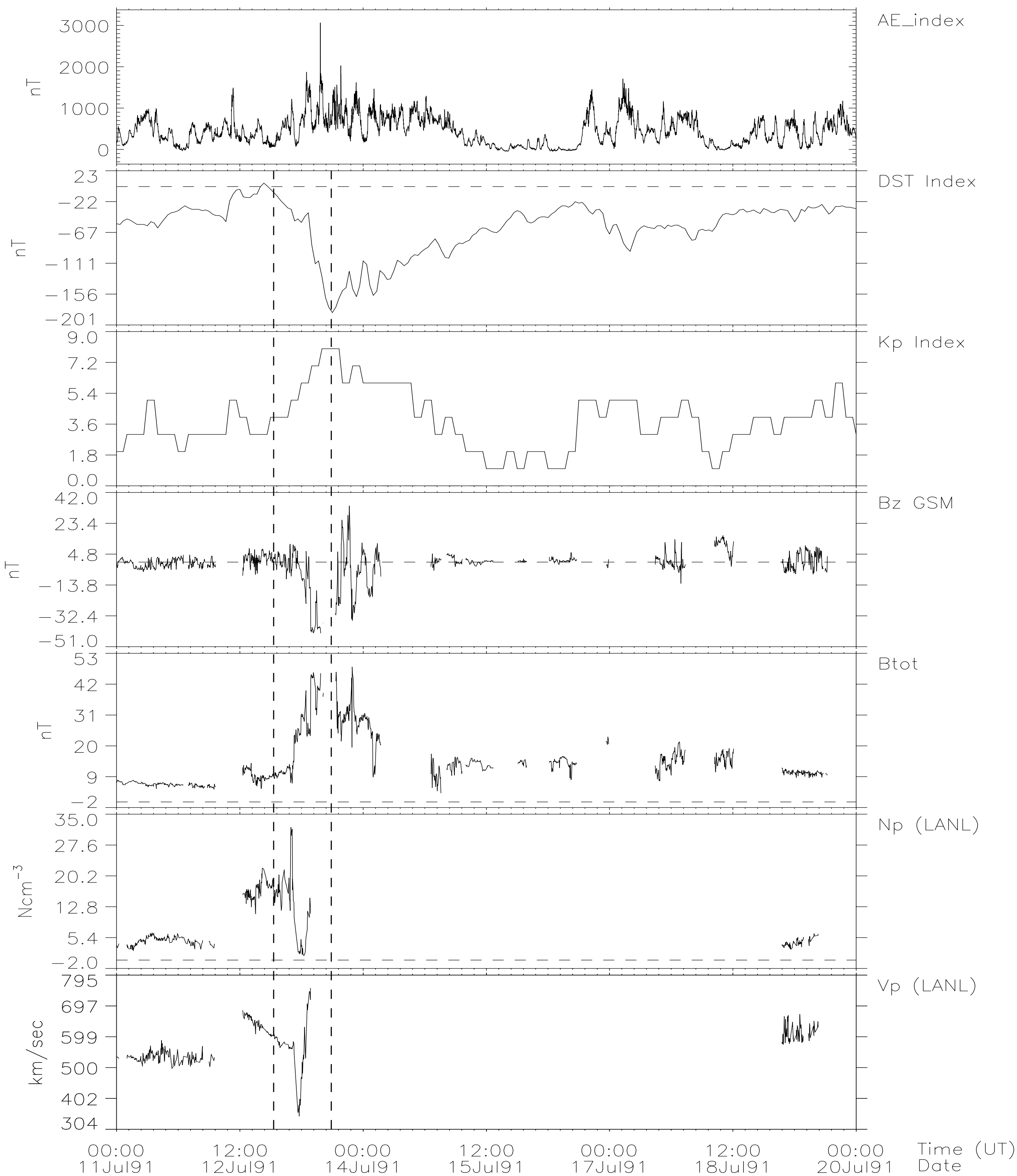


E.3 Midnight Storm: Discussion

- Storm occurred when CRRES apogee was near 00 MLT (See Section B). Moderate to small storm with a two-phase onset and classical recovery.
- Large +ve angles of magnetic field H/V - model indicates strong stretching of field also at midnight, mainly limited to L values beyond 5, due to the weak storm strength.
- E_y also shows a two intensifications corresponding to the two phase onset. Again recovery is marked by the disappearance of E_y.
- Ring current ions intensify strongly during the second onset phase and are visible at CRRES immediately. Electrons show substorm injections at large L only.

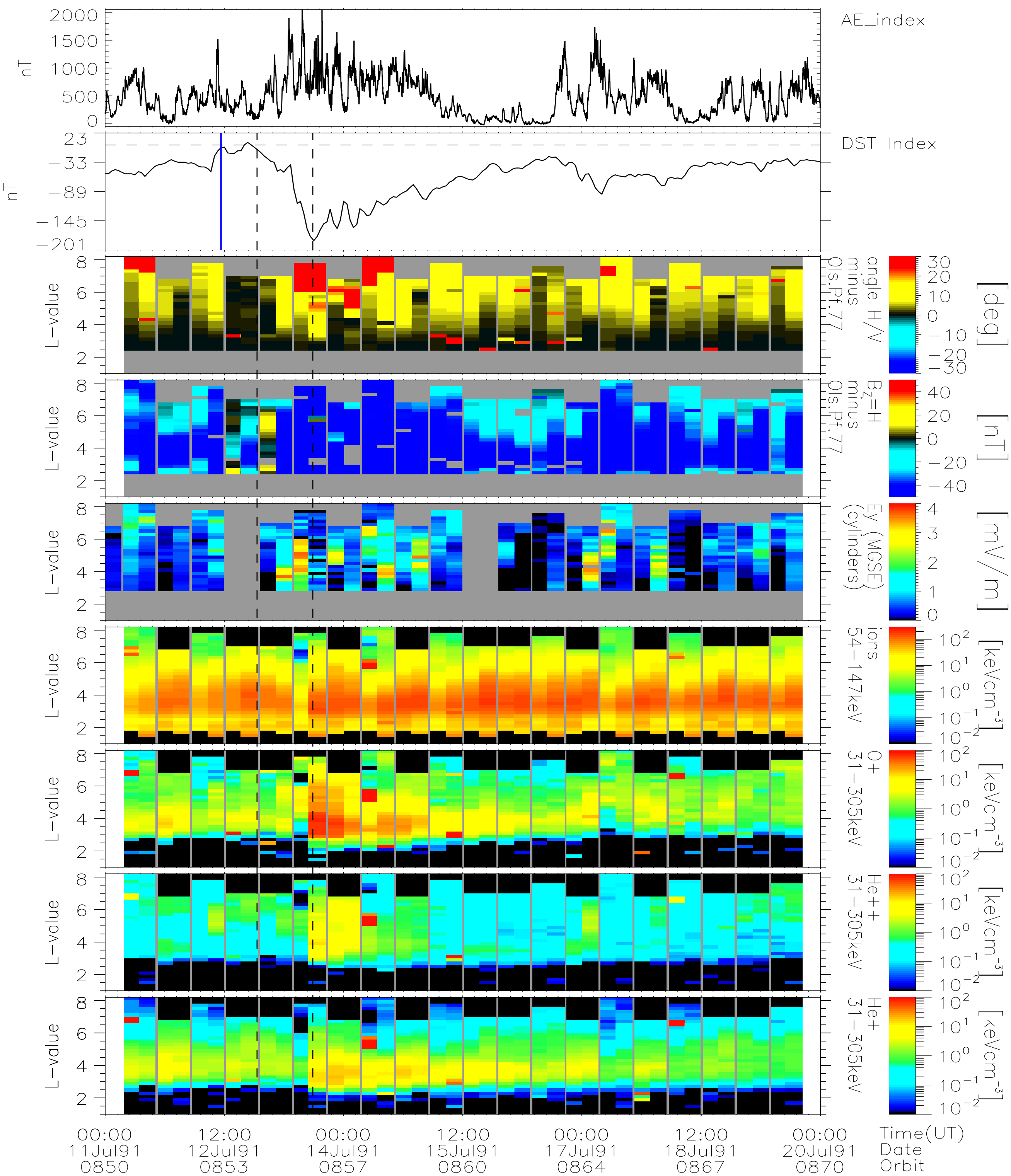
At midnight CRRES sees the full convection paths of ring current ions and this sees an intensification right at onset.

F.1 Afternoon Storm: Geomagnetic Conditions



F.2 Afternoon Storm:
Radiation belt conditions

The Energetic Particle Team at Los Alamos National Laboratory



F.3 Afternoon Storm: Discussion

- Storm occurred when CRRES apogee was near 18 MLT (See Section B). Classic southward turning of B_Z, recovery initiated by northward turning of B_Z.
- Very large +ve angles of magnetic field H/V - model indicate very tail-like configuration in the afternoon sector. Stretching of field down to L=4, indicating a strong storm.
- E_y is moderate during onset. Several later intensifications relate to strong substorms. Recovery is marked by the disappearance of E_y.
- Ring current ion response is weak for protons but strong for other ion species.

Weak H^+ response indicates enhanced convection of an already accelerated population - this storm occurs during a very active CRRES period [*Friedel and Korth*, 1997] and the radiation belts are already "charged" - as can be seen the persistent stretching of the field even before the storm. Only "new" particles are solar wind/ionospheric ions.

G. Summary

- CRRES particle data in an "overview" format (L versus time, resolution half an orbital period) allows tracking of the radiation belt particle population during storms and substorms.
- Data from several storms, observed at different magnetic local time, show large stretching (flattening) of the magnetic field down to L-values below L=4 (depending on storm size). The flattening is not only observed at midnight, but also at dawn and dusk.
- An enhanced dawn-dusk electric field (convection electric field) is observed during the main phase of the storm and vanishes during the recovery of the storm.
- Ring current ions (protons and He^{+}) decay during the main phase of the storm and intensify at the beginning of the recovery phase of the storm.
- Substorm injections can feed the ring current at larger L-values.
- From the beginning of the main phase of the storm He^{2+} ions (solar wind) have access to the magnetosphere.

G. Summary - cont.

- O^+ ions are observed during the main phase of the storm and originate from the ionosphere.
- An intensified symmetric ring current is observed at the beginning of the recovery phase and not during the main phase of the storm.
- During the main phase of the storm enhanced local currents (asymmetric) cause the depression of the magnetic field H-component at dawn and dusk.

H. References

Friedel, R. H. W., and A. Korth, Review of CRRES ring current observations, *Adv. Sp. Res.*, *20*, 311–320, 1997.

Korth, A., G. Kremser, B. Wilken, W. Güttler, S. L. Ullaland, and R. Koga, Electron and proton wide-angle spectrometer (EPAS) on the CRRES spacecraft, *J. Spacecr. Rockets*, *29*, 609–614, 1992.

Singer, H. J., W. P. Sullivan, P. Anderson, F. Mozer, P. Harvey, J. Wygant, and W. McNeil, Fluxgate magnetometer instrument on CRRES, *J. Spacecr. Rockets*, *29*, 599–600, 1992.

Wilken, B., W. Weiss, D. Hall, M. Grande, F. Soeraas, and J. F. Fennell, Magnetospheric ion composition spectrometer onboard the CRRES spacecraft, *J. Spacecr. Rockets*, *29*, 585–591, 1992.

Wygant, J. R., P. R. Harvey, D. Pankow, F. S. Mozer, N. Maynard, H. Singer, M. Smiddy, W. Sullivan, and P. Anderson, CRRES elecetric field/Langmuir probe instrument, *J. Spacecr. Rockets*, *29*, 601–604, 1992.